Information node characteristics for model construction

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Abstract: The possibility to evaluate the effectiveness of different information systems appeals to many organizations. One way of obtaining this information is through simulation. However, today's available definitions of information nodes (i.e. pin board, e-mail, phone) are too vague and immeasurable. Thus this work strives to produce a theoretical material for defining information nodes. Inductive reasoning was used for our theoretical research, where indicators defining information nodes were produced and applied in a model. This model can be employed in various situations and be used as a base for model construction.

To clarify the theory we display a way of constructing an application model, usable as a base in simulations. From the theoretical material the indicators were reduced and made operational into variables, to be useful in a more practical manner. This resulted in a hierarchical structure over classes of information nodes and corresponding variables. We see this part of our research as a guidance and aid in the work with model constructions, functional in different simulations.

Keywords: information node, information flow, quantitative variables, simulation, AMSIDO.

I. INTRODUCTION

Organizations invest a large amount of money in information systems [1] and even though the knowledge of the investments' effectiveness is deficient [2], investments increase rapidly as the organization grows [3]. This is a non-lasting equation, which may result in ineffective information flow. Thus organizations need a way of defining which information systems to use.

Earlier research has produced strategies on how organizations should manage their information technologies so that they more effectively contribute to achieving organizational objectives [4]. Others have made attempts to measure the communication effectiveness through comparing the relationship between investment in information technology and organization's profitability and productivity [5]. Those studies have all tried to define information technology but have not succeeded in making the effectiveness of information flow measurable.

Researchers in the AMSIDO[1] project initiated a different approach to this problem. In an attempt to evaluate information systems they simulate an organization and its information flow. The project aims to appraise the effectiveness and efficiency of an information system in an organization [2]. One crucial part of the simulated system is the deficient descriptions of information technology. Those descriptions are in the current state too simplified and lack the complexity of reality.

Thus the objective of our project is to construct an operational definition of information nodes (see definition below), in an information flow context, within the frame of the AMSIDO project. By formulating an operational definition we aim to make it measurable and observable. The definition will be expressed in a theoretical model and an application model. In extension these models will support construction of information system models and facilitate evaluation between different information systems through simulation.

To be able to meet our objective we will work with two research questions; 1. Through which areas can we theoretically define information nodes? 2. In what way can these areas be made operational?

To clarify the exploratory nature of this paper the following assumptions have been made: The first assumption we make is that it is possible to describe information nodes using concrete and measurable variables. Secondly, we believe it is possible, supported by the variables of information nodes, to simulate and evaluate an information system.

The rest of this paper is organized as follows: Section II describes the method we used. In section III we discuss our worldview, which ends in a description of our concept in focus followed by a general discussion about modeling. Section IV includes our definition of information nodes and in section V our theoretical model is presented. In section VI we illustrate how theory can be transferred into an application model. Section VII includes a general discussion about the result.

II. METHOD

In order to define the information nodes we chose to use seminars for generation of possible descriptive indicators. Structured techniques for evaluation, classification and modeling of the indicators were used. From this material, variables were selected in order to construct a class hierarchy. The validation was conducted in two phases (see figure 1).

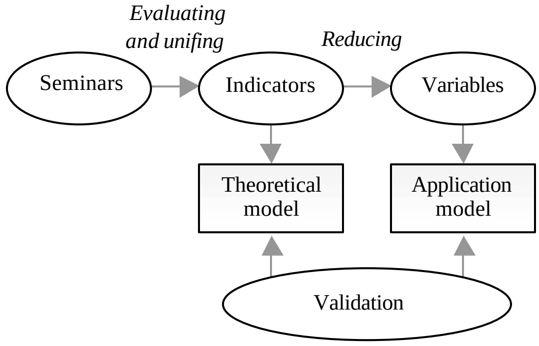

Fig. 1. Model of method

[1] AMSIDO (Agent-based Microworld Simulation of Information Distribution in Organizations). For further information visit http://gathering.itm.mh.se/amsido .

A. *Method of inquiry*

We used an inductive approach to engender concrete and measurable indicators. During our research General System Problem Solving (GSPS) framework and what is called epistemological hierarchy of system described in Klir [8] and similar in Ziegler [9] was a source of inspiration. However only level 0 to 2 was under consideration.

Two seminars were conducted with different reference groups. The members of the groups are both from the information science and technical field as well as the academic and business area. They represent broad spectra of different kinds of knowledge and experience[2] and therefore approached the problem from different angles, which resulted in a more varied outcome. The procedures of the seminars were influenced by the Idea writing method and the Nominal Group Technique (NGT) method, both useful in a creativity-process [10]-[11].

At the first seminar the majority of the partakers had prior understanding of our research. As well as one trigger question exemplifying information nodes were used to initiate the process.

The second seminar was held with participants with no prior knowledge of our research and the procedure was similar to the first seminar. As an additional idea trigger predetermined group-names for indicators were presented.

The next phase was to theoretically evaluate the generated indicators and unify the two outcomes. To be able to appraise if the indicators were within the delimitation of our objective we constructed a chart (see figure 2).

The first axis delimits purely human aspects. Only indicators that describe the interaction between humans and information nodes are included in the model. Delimitation towards information is illustrated on the second axis, were indicators that exclusively describe information are excluded in the model. The last axis delimits environmental indicators, which are located too far from our area of interest i.e. external indicators like rules and laws. Using the chart, we consider all the indicators inside of the dashed lines as relevant indicators.

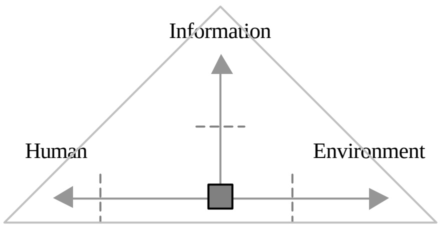

Fig. 2. Delimitation chart.

When only relevant indicators remained, clusters were constructed and the indicators categorized. From this material we were able to construct a model over the areas of indicators, which defines an information node.

[2] For more information about the reference groups visit http://gathering.itm.mh.se/amsido/incmc.

B. *Application model*

To be able to explain our theoretical work we constructed an application model in form of a hierarchical structure over the information nodes. In order to make the hierarchy manageable a reduction among the indicators had to be done. For this phase our work was based on the methodology referred to as reconstruction analysis [8]. It defines how a system can be broken down and declared with sufficient variables for reconstruction of the original system with an acceptable degree of approximation [12]. We used two simplification strategies in order to reduce complexity. One was exclusion of variables and the other was coarsening of variables, both defined in Klir [12].

In the construction phase an object-oriented approach were applied since it has the capability of reducing complexity and making a comprehensible structure. Thus was the conversion to Java apparent, which is the program language applied for our application model. Java is platform independent and well suited for simulations. The overall goal with the hierarchy is to implement it in a simulation, though the realization is not within the frame for our research.

C. *Validation*

The last phase in our research included validation of our work with content-related validity methods [7], a theoretical approach appropriate in design situations.

As a first step the face validity [13]-[14] of our theoretical work was tested. The areas of indicators and the indicators themselves were presented and discussed with people with some level of expertise in our area of research.

Secondly the application was validated by the use of case scenarios. The adequacy of variables related to various information nodes was examined through the use of a questionnaire.

III. WORLDVIEW

As a first step it is necessary to select the aspects that are relevant to our area of interest. As Ashby declares, every object contains no less than infinity of aspects and therefore infinity of possible systems [15].

In order to make our selection of relevant variables we have to state our view of information systems, which leads to our concept in focus. This concept will be employed in modeling. Thus a general discussion follows to declare our view of modeling and models' complexity.

A. *Information system*

There are numerous definitions of information systems. Influenced by cultural differences two main views can be discerned [16].

The North American view put focus on technology. The definition of information systems involves information technology; its function and development. [17]

The European view on the other hand focuses on the inter-relationship between organizations and technology. Information system involves gathering, processing, storing, distribution and use of information and associated technologies. [16] The Scandinavian view, as a branch of the European view, stresses even more the importance of humans in information systems [18]. Langefors define information systems as a social concept where the organisation is a vital part for using the data system and interpreting the data into information. [19]

Another related subject is information flow, which is an important part of any information system. As a pioneer, Shannon introduced information theory where he describes communication as a transfer of information. Transmitters and receivers (technology) are connected and transferring information through a channel. No consideration is taken to how the source or destination (humans) is interpreting the information or in which activities they result. [20]

Later researchers have taken an interest in the parts excluded in Shannon’s theory. Information science nowadays mostly focuses on information, how it is interpreted, what other qualities and circumstances information is dependent on and how to measure information content. [21]

B. *Concept in focus*

In our effort to produce and present suitable indicators to define information nodes in an information system we have our focus somewhere in between the two main views stated above.

Earlier research has focused on one type of information channel where others have been rejected, i.e. using one information technology implies not using another. Normally organizations make simultaneous use of different information technologies and thus the result may not be as inclusive as reality [6]. In similarity to GST [22] we have a holistic approach to information nodes, i.e. we see information nodes as small open systems that interact with the environment, each other and the users. Rather than looking at the information nodes alone, we focus on the interaction and relation between the parts that unite them into a whole (see figure 3).

Strictly human and information aspects are however excluded. Thus according with Shannon, there is no consideration of the interpretation of the information or the resulting human actions.

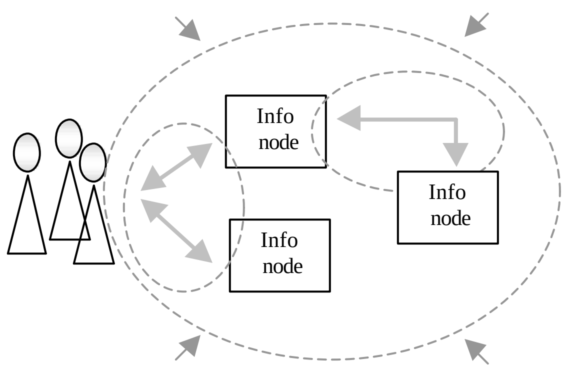

Fig. 3. Conceptual model of our study in focus.

C. *Modeling*

The word model is a rather wide conception, which Miller classifies to include everything from a loose verbal analogy to a precise mathematical structure [23].

Models are never exact duplicates of reality [23]-[25] and we do not expect them to be [25]. Miller declares that if a model were to include all the elements of the system, the model itself would be too complex to handle [23].

Van Gigch talks about complexity in the terms of generality/specificity. Models with a high specification-level are defined in detail. Van Gigch states that these models have a greater probability of success however they are also less realistic since they are built on more assumptions and constraints [24].

When a model gets to complex and unmanageable, a simplification must take place. In every simplification we loose relevance of prediction of the real world. [12] To simplify Klir defines two kinds of complexities to keep in mind; descriptive complexity, i.e. information that is required to define a system and uncertainty-based complexity, i.e. information needed to resolve uncertainty imbedded in the system. The two kinds conflict with each other. If we reduce one the other is likely to increase or at best remain the same [12].

Miller discusses generality/specificity in similarity to van Gigch, although with a different content. He says that a model is general up until precise quantities are stated for its elements and relationships. Then it becomes a model of a specific system or subsystem. [23]

Randers states that every model has several characteristics and dependent on the purpose of the model different ones are stressed [26]. To be able to construct a model with measurable values i.e. useful for simulations, its variables have to be made operational. The ways a phenomenon is made operational are numerous. Which way to choose is dependent on the nature of enquiry [27] and on the hypotheses the work is built.

IV. DEFINITION OF INFORMATION NODE

For comprehension of our project we had to define a generic term of the information technologies in focus. The term we chose was information nodes. Previous researchers have defined information technologies as information products, channels or sources [4], [28], [29]. Based on preceding research and combined with our area of interest, we characterize information nodes as follows:

An information node represents a concrete information source, which is capable of transmitting, receiving and/or storing information. Through the information nodes textual, audio and/or graphical information is presented for use.

The nodes are often essential tools in an organizations internal and external communication process and at the same time resources of information from which the organization can gain new knowledge.

V. OUR PROPOSAL FOR DEFINING INFORMATION NODES

To be able to define information nodes we choose to illustrate it in a model. The model was created from the indicators generated at the seminars and consists of three categories with subcategories, which describe our concept in focus (see figure 4). Within each subcategory a number of indicators[3] are to be found. In order to reach a specific intention a selection among the indicators can be done. Hence our model should be regarded as a base for constructing new models.

Our main objective with the model is not to produce a perfect reproduction of reality but rather to create more insight of the problem. We do not include every possible indicator in the model, only those regarding information flow. Still the model is specific in the meaning van Gigch declares.

Through the use of categories the idea is to make the model simple to understand and easily expandable. The structure is chosen to give a comprehensive view of the indicators. Our model is to a great extent qualitative and it is made general in the meaning Miller declares, i.e. no precise quantities are stated, to be able to explain various kinds of scenarios.

As previously noted, the indicators were generated in seminars. Most of the indicators were similar in the two seminars, which indicates their significance. The indicators that varied were more technical oriented in the first seminar as in contrast to the second seminar, where there was a human orientation. The difference might be due to the dissimilar background of the participants. After theoretical evaluating and uniting the two outcomes[4] 63 indicators remained and became our theoretical model.

The following categories are found within the model: information flow, user interaction and environment. The category *Information flow* describes the communication between the information nodes. The *User interaction* category describes the interaction between a user and an information node. *Environment*, the last category describes areas that effect and are important to the information flow but are not directly associated with it. A discussion about the indicators in each category is stated below.

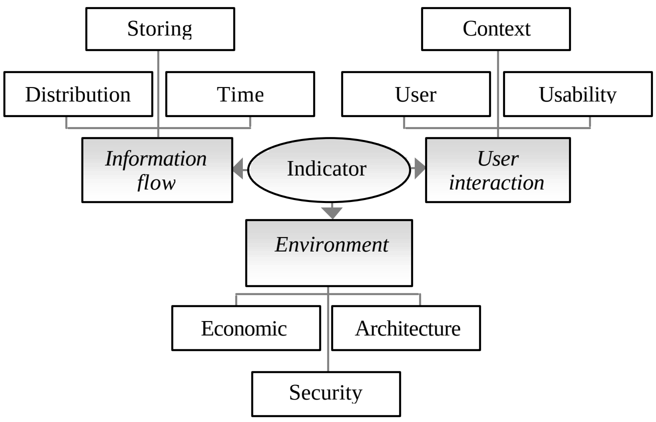

Fig. 4. Theoretical model of information node indicators.

[3] For further information about the indicators visit http://gathering.itm.mh.se/amsido/incmc.

[4] For more exhaustive information about the united outcome visit http://gathering.itm.mh.se/amsido/incmc.

A. *Information flow*

This category focuses on the more technical aspects and the communication between the information nodes themselves. It is divided into three subcategories; distribution, storing and time.

In the first subcategory, *distribution*, we find indicators describing how the information nodes communicate and how information is distributed among the information nodes. There is a focus on which type of information that can be presented at the node and if the information node is capable of transferring one type of information into another. Also how information is sought for is reflected on as well as the possibility of receiving real time information or if the information can be found later.

The second subcategory, *time*, includes indicators related to all the other categories but since our research has a close connection to simulations our opinion is that the importance of time justifies a subcategory. A broad spectrum of indicators is integrated resembling booting time, the information's exposing time etc.

The third and last subcategory, *storing*, includes indicators describing information nodes capability of storing, buffering and holding a hierarchical structure.

B. *User interaction*

This category deals with the user and their interaction with the information node. It embraces a wide area of indicators including everything from indicators directly related to the user or information node to indicators effecting the interaction between the two. We have divided this category in three descriptive subcategories; user, usability and context.

User focuses on indicators that are linked to a user of an information node. Discussions on how many users that simultaneous can interact with an information node and the physical distance between users and information nodes when interacting are included.

Indicators in the subcategory *usability* reflect on how user-friendly an information node is. These take into consideration the structure of information presented on the information node, how well arrange the information is and the quantity of information that can be presented. The complexity of the information node and what knowledge and activities that is required is another part in focus. Ergonomic is also an important aspect to keep in mind in the usability category.

The subcategory *context* describes aspects that effect the interaction between human and information nodes, but is not directly related to the actual information node. An important area in an organization is the noise that can occur, which is brought to light here. Also the human conception in relation to the information nodes is discussed. For example can an information node infuse different levels of confidence and are different surplus values obtained when using different kinds of information nodes? Another crucial part for an organisation is how important the information node is for the spread of information. Some information nodes can be used more frequently than others, why it is important to weight the information nodes relevance in an organisation.

C. *Environment*

This category describes aspects that are important when measuring the effectiveness of the information flow related to the information nodes. The subcategories for this area are: economic, architecture and security. None of these subcategories are possible to relate directly to either information flow or user interaction but are indeed important to the overall picture.

In an organization *economics*, the first subcategory is important and may be the crucial feature in the decision making procedure of which information system to chose. Installation and maintenance cost as well as lifespan of an information node are explored areas.

The second subcategory *architecture* regards environmental aspects and physical characteristics of the information nodes as well as different kinds of requirements for using and placing an information node.

Security is the last subcategory in our model. This area describes error handling and access of information. Another view of security is how the organisation accesses information and the information nodes capability of encrypting information.

VI. THEORY TO APPLICATION

In order to clarify our theory an application model was constructed usable as a support for simulations. Through this work we demonstrate and guide how to use our indicators in creating a model for a specific purpose.

As we stated before there are several ways to construct a model dependent on the purpose [26]. Our model should be regarded as a base in the AMSIDO project [1]. We needed a model that has the possibility to be general in different levels and that is transferable into simulations, which found expression in a class hierarchy of information nodes.

The different information nodes diverge in many aspects however using a class hierarchy a generalization structure [30] is achievable. It enables us to place the different information nodes at suitable levels in the hierarchy and thereby they become more manageable.

A. *Class hierarchy*

The hierarchy[5] includes abstract and concrete classes as well as interfaces (see figure 5), which in an accurate arrangement makes it possible to place any information node within the hierarchy. In figure 5 exemplifying information nodes demonstrate how this is achieved. Through the use of interface redundancy is avoided and multiple inheritances is achievable.

To be able to use the hierarchy as a base in a simulation the indicators from our theoretical model had to be translated into quantifying variables, which are characterized as being unambiguous and measurable [27].

In addition this enables the model to express specific values as declared by Miller, and define a specific information node.

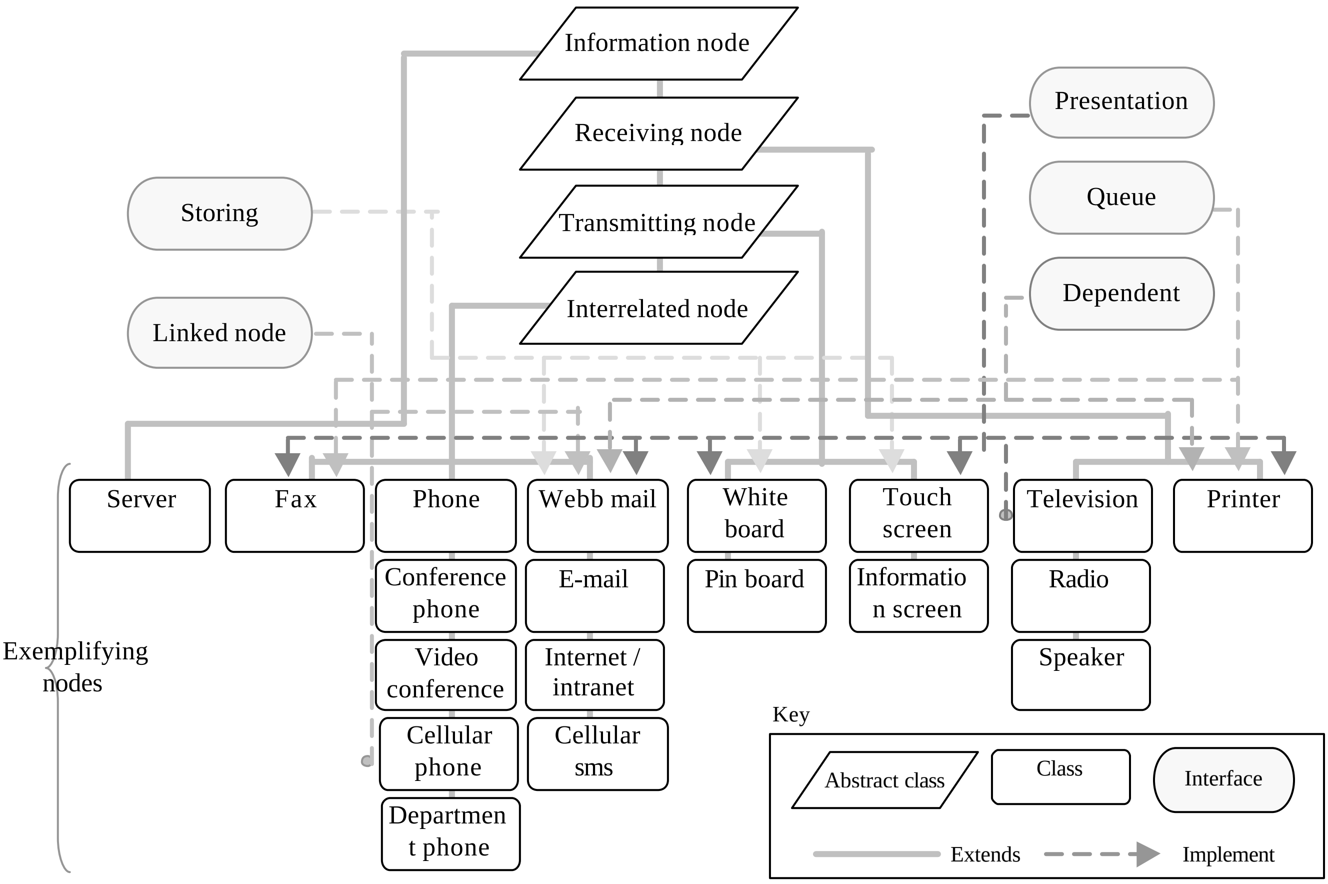

Fig. 5. Application model and exemplifying nodes

[5] For a more detailed version of the class hierarchy visit http://gathering.itm.mh.se/amsido/incmc.

To simplify and make the model manageable we chose to decrease the descriptive complexity by reducing the number of variables. The research objective determined which variables to exclude [25]. This way, when using van Gigch definition of specific and general, our model falls closer to the latter classification. By reducing the variables a generalization is achieved.

The remaining variables were then described as *concrete* or *estimated* unlike the proposition in GSPS: *basic* or *supporting* [8] and given a methodological distinction. The entities defined by the concrete variables are possible to observe and they are also measurable. However the estimated variables define abstract entities related to the users, which are problematical to observe and measure. Thus these variables had to be made operational. Most of the operational estimated variables are measured by means of a discrete scale or in time. In a combination between the estimated and concrete variables a phenomenon can be defined. In total 32 variables were recognized and implemented in the class hierarchy.

To be able to use the model accurately a definition of information is required, which includes making it operational.

In the following sections the classes, corresponding variables and their suggested values are explained.

Information node: This class is an abstract class, which defines the most basic variables of the information nodes. Information nodes that originate from this class don't have any human users nor can they present any information.

Name	*Label*
Description	Unique identifier.
Value	Name
Name	*Error frequency*
Description	Estimated average amount of error per unit of time.
Value	Error/time
Name	*Group belonging*
Description	Identifier for information node group i.e. computer network.
Value	Group name
Name	*Type of information*
Description	The type of information the information node can manage.
Value	Textual, audio, graphical.
Name	*Physical position*
Description	Physical position of information node.
Value	Coordinate x, y.
Name	*Physical size*
Description	Physical size of information node; length, width, height.
Value	Meter, centimeter, millimeter.
Name	*Placing requirement*
Description	Requirements for insertion of information node. If no value is set the information node is mobile.
Value	Desk, wall, mobile etc.
Name	*Distribution error frequency*
Description	Estimated amount of misplaced information per unit of time.
Value	Amount of information/time

Receiving node: Information nodes that originate from this abstract class are those who have the ability to present information to a user or users.

Name	*Presentation capacity*
Description	Estimated maximum amount of simultaneous information presented at the information node.
Value	Amount of information.
Name	*Numbers of simultaneous receivers*
Description	Estimated maximum numbers of simultaneous receivers (humans) at information node.
Value	Number of receivers.
Name	*Physical receiving distance*
Description	Estimated maximum distance between human and information node when receiving information.
Value	Meter, centimeter
Name	*Information category*
Description	Assumed information category i.e. order, instruction presented at information node. Variable values are found in variables defining information.
Value	-
Name	*Relevance/Weight importance*
Description	Estimated importance/relevance of the information node in organization. Combine with *information category* i.e. together they define where the receivers are expected to search for categories of information.
Value	Discrete scale.
Name	*Trustworthy*
Description	Estimated trustworthiness of information node i.e. information received at a mobile sms may not be as trustworthy as on e-mail.
Value	Discrete scale.
Name	*Attention factors*
Description	The attention factors triggered from an information node when information package arrive.
Value	I.e. Telephone signal, e-mail attention
Name	*Receiving ownership*
Description	Who/whom has the rights to receive information from information node i.e. the owner of a phone, e-mail.
Value	Name/names.
Name	*Receiving learnability*
Description	Estimated difficulty to learn how to receive information from information node. Combine with time to capture information and presentation clearness.
Value	Discrete scale.

Transmitting node: This abstract class defines variables that are related to transmitting traits. Information nodes, which originate from this class, have the ability of transmitting information.

Name	*Numbers of simultaneous transmitters*
Description	Estimated maximum number of simultaneous transmitters at an information node.
Value	Number of transmitters.
Name	*Physical transmitting distance*
Description	Estimated maximum distance between human and information node when transmitting.
Value	Meter, centimeter
Name	*Transmitting learnability*
Description	Estimated difficulty to learn how to transmit information from information node.
Value	Discrete scale.
Name	*Time to add information*
Description	Estimated time to transmit information from information node. Combine with transmitting learnability.
Value	Minutes, seconds
Name	*Transmitting type*
Description	Communication type used when transmitting information.
Value	Simplex, duplex.

Name	*Transmitting ownership*
Description	Who/whom has the rights to transmit information from information node i.e. phone, e-mail.
Value	Name/names.

Interrelated node: This abstract class represents information nodes that have the capability of communicating with similar information nodes or information nodes in other classes.

Name	*Related information node classes*
Description	Other classes of information nodes the information node can communicate with.
Value	Class name/names

Linked node: This interface refers to information nodes that are linked together trough a physical device.

Name	*Super- node label*
Description	Defines which super-node the information node is link to i.e. computer is super-node for e-mail, internet etc.
Value	Name

Queue: Information nodes that will use this interface are those who have the capability of accepting a queue.

Name	*Buffer queue*
Description	Concrete amount of maximum information buffered in an information node queue.
Value	Amount of information.

Presentation: This interface applies to information nodes that have the ability to present textual information.

Name	*Presentation clearness*
Description	Estimation of how well arranged and clear-presented textual information is on an information node.
Value	Discrete scale
Name	*Time to capture information*
Description	Estimated time to capture information at information node. Combine with presentation clearness.
Value	Minutes, seconds.

Dependent: Information nodes that utilize this interface are those who are dependent on another information node. Dependent information nodes can not exits without the other node.

Name	*Dependent on*
Description	Name of other information nodes the information node is dependent on i.e. e-mail x id dependent on server y.
Value	Name/names

Storing: This interface is dedicated to information nodes that have the capacity of storing information.

Name	*Storing capacity*
Description	Estimated maximum amount of stored information at an information node.
Value	Amount of information.
Name	*Storing time*
Description	Concrete period of time before information is automatically erased from information node.
Value	Days, minutes, seconds.

Name	*Search time*
Description	Estimated search time to find information at information node.
Value	Minutes, seconds.

VII. CONCLUDING REMARKS

The objective of our research was to construct an operational definition of information nodes. The result is a theoretical model for defining information nodes and a corresponding application model, usable as a base in simulations.

Using our first research question, areas were defined for the theoretical definition of information nodes. Our theoretical model has a general point of view and should be considered as a base for model construction. We believe it useful in various situations and valuable for different purposes.

Our second research question helped us to make the theoretical model operational. By the construction of the application model our aim is to demonstrate and guide how to use the theoretical model. Java was the program language used in the hierarchy, which makes it easy to develop further. This makes it functional in a wide range of simulations.

Inductive reasoning, which was used in our research, invites to some source of errors. Nevertheless, we find the use of seminars and NGT as idea generating methods rewarding, with a satisfactory outcome. We judge the fact that many of the indicators occurred on both seminars informing on the relevance and importance of the indicators. We do not believe that the use of other methods or additional seminars would have improved our product to a great extent.

Since a model is a simplified image of reality some of its credibility is receded when modeling. We have stressed usability during the modeling phase. This has resulted in a reduction of descriptive complexity, which probably have had a negative impact on the uncertainty-based complexity. However, relevance is gained when allowing some uncertainty-based complexity.

Another source of errors is the operational part, which always includes some degree of misjudgment [27]. Still, we believe acceptable assumptions can be drawn from the operational variables.

The theoretical model, the hierarchy and corresponding variables have been constructed within the frame of the AMSIDO project's objective. However, with another focus the model would have been different. We cannot with total certainty say that our model will be able to manage future information nodes. However, we believe that in the foreseeable future, the variables will remain the same even though new information nodes appear on the arena.

Within the frame for our research it is not achievable to examine all the different kinds of errors mentioned above or to make a complete validation. However by using content-validity methods we can comment on the validity of our research content. Even though the relevance of our theoretical model cannot with certainty be established, through logical reasoning some degree of relevance has been confirmed. Case scenarios indicate that the variables included in the application model are adequate and measurable. We cannot with confidence state the reliability of the application model. However we believe it can contribute and add value to different kinds of simulations.

Further research of interest in this area would be implementing our application model or another application of our theory into a simulation. When this is accomplished a more advanced level of validation can be achieved. Our research can also be combined with other areas of interest i.e. humans and procedures, for evaluating different information systems.

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